US008081422B2

(12) **United States Patent**
Shannon et al.

(10) **Patent No.: US 8,081,422 B2**
(45) **Date of Patent: Dec. 20, 2011**

(54) **POWER DISTRIBUTION SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 61 days.

(21) Appl. No.: **12/418,676**

(22) Filed: **Apr. 6, 2009**

(65) **Prior Publication Data**

US 2010/0085687 A1 Apr. 8, 2010

Related U.S. Application Data

(60) Provisional application No. 61/102,039, filed on Oct. 2, 2008.

(51) **Int. Cl.**
H02B 1/26 (2006.01)

(52) **U.S. Cl.** **361/624**; 361/637; 361/648; 361/729; 439/76.2; 307/43

(58) **Field of Classification Search** 361/634, 361/644, 652, 673, 679.01, 728, 752, 788, 361/796, 800, 622, 624, 629, 637, 641
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,737,194	A *	4/1998	Hopkins et al.	361/800
6,693,371	B2 *	2/2004	Ziegler et al.	307/64
6,796,808	B2 *	9/2004	Hosoe et al.	439/76.2
7,154,761	B1 *	12/2006	Camerlo et al.	361/788
7,324,335	B2 *	1/2008	Sueyoshi	361/679.33
2006/0040563	A1 *	2/2006	Fuller et al.	439/668
2006/0171133	A1 *	8/2006	Pedoeem et al.	361/796

* cited by examiner

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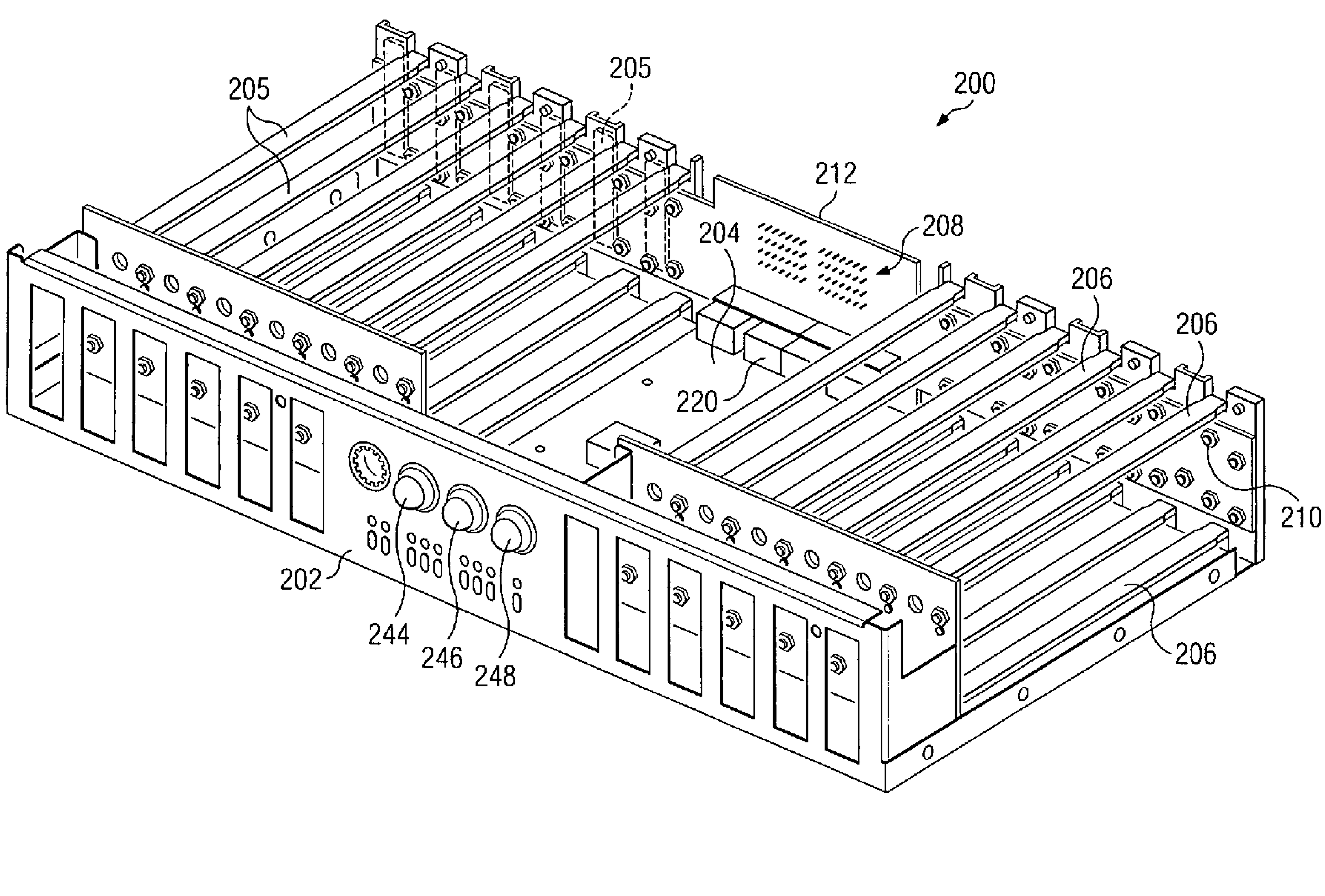
(57) **ABSTRACT**

A back-wiring board that connects to a main circuit board of a power distribution system. The back-wiring board includes a plurality of connectors configured to mechanically secure to a plurality of bus bars. The connectors of the back-wiring board are further configured to receive a voltage signal from the plurality of bus bars and to transmit the voltage signal to the back-wiring board. The back-wiring board also includes a plurality of wire-wrap pins integrated into a surface of the back-wiring board, wherein the wire-wrap pins are configured to receive data input signals. The back-wiring board includes a right-angle connector configured to couple the back-wiring board to the main circuit board.

16 Claims, 5 Drawing Sheets



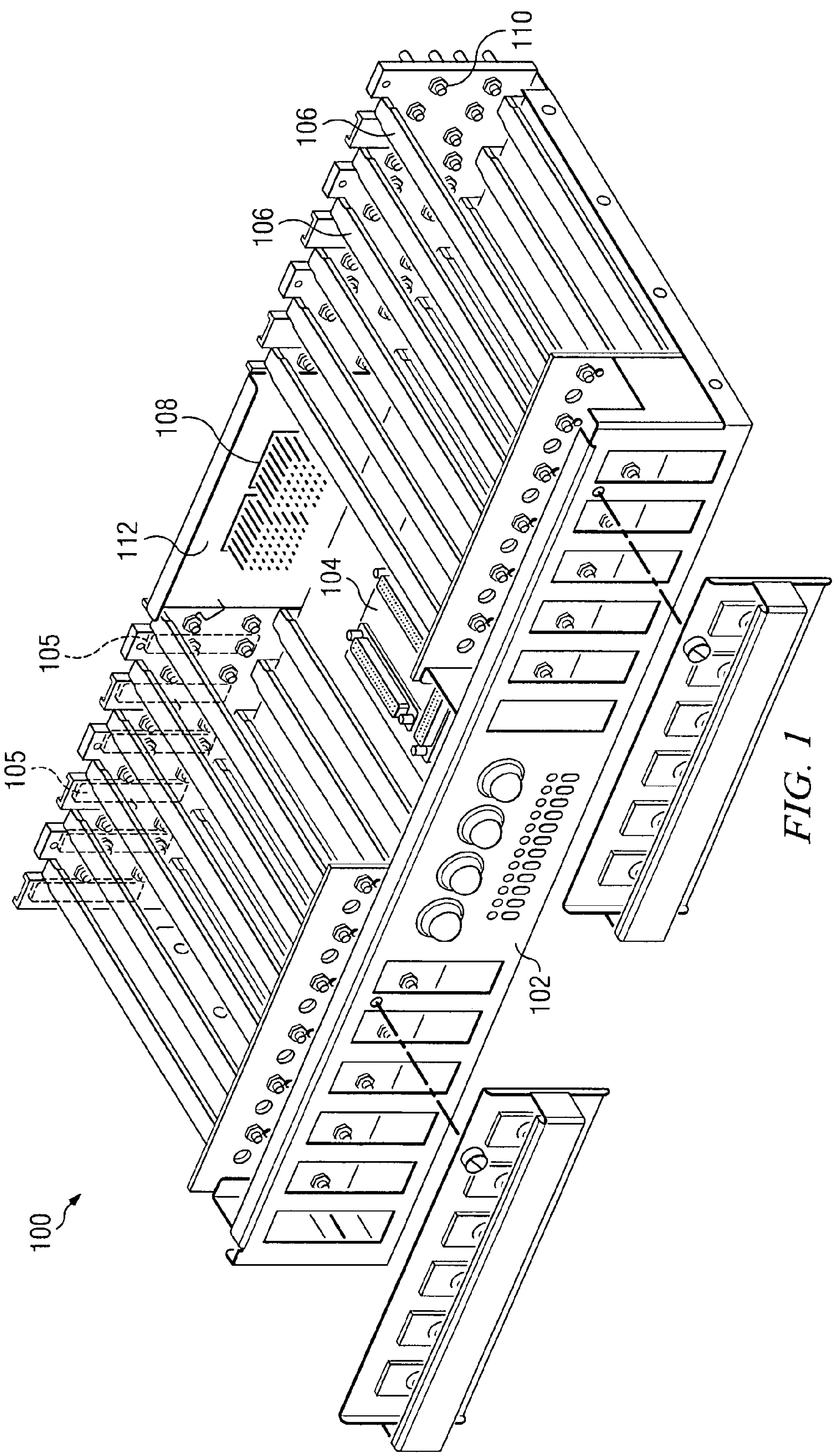


FIG. 1

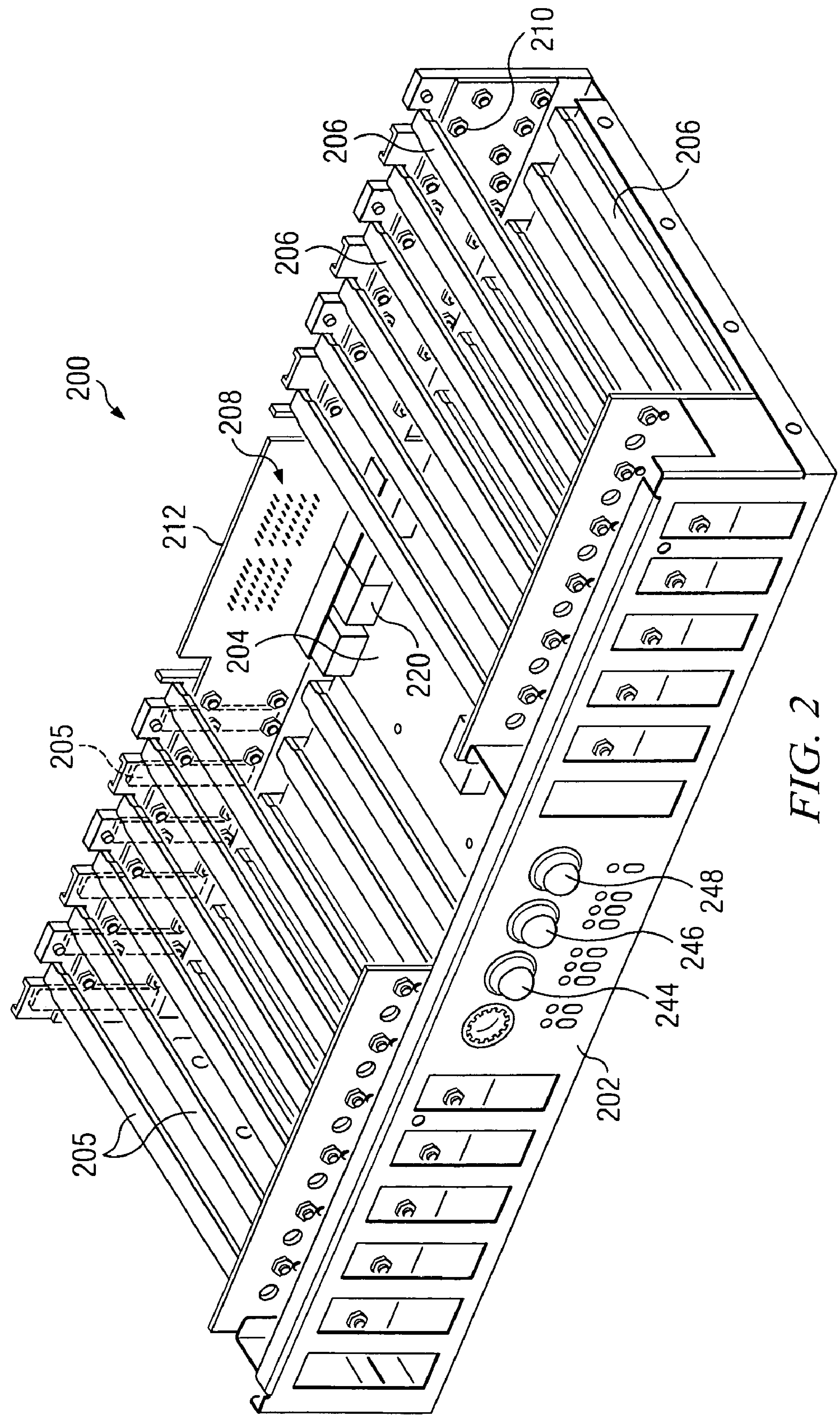


FIG. 2

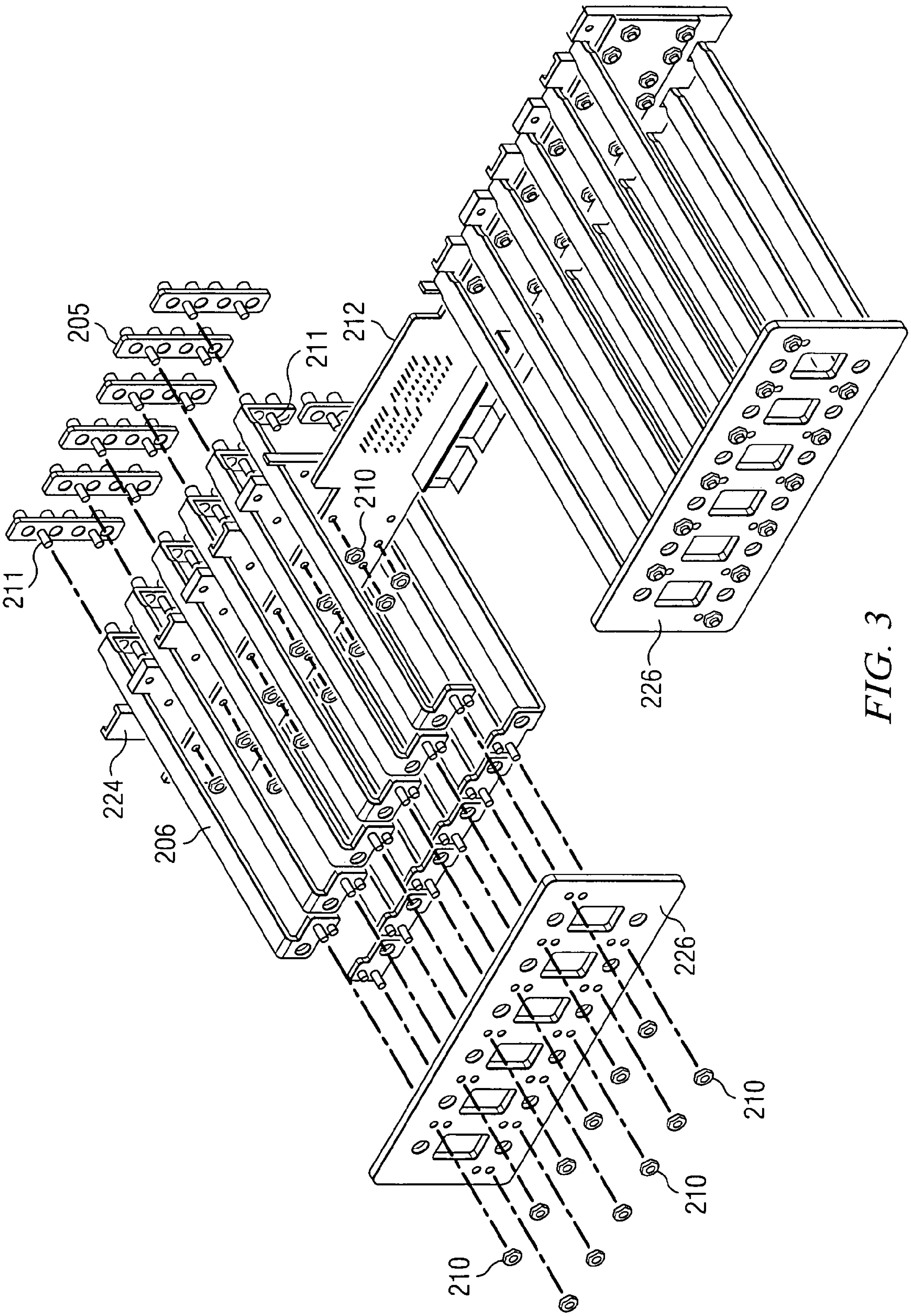


FIG. 3

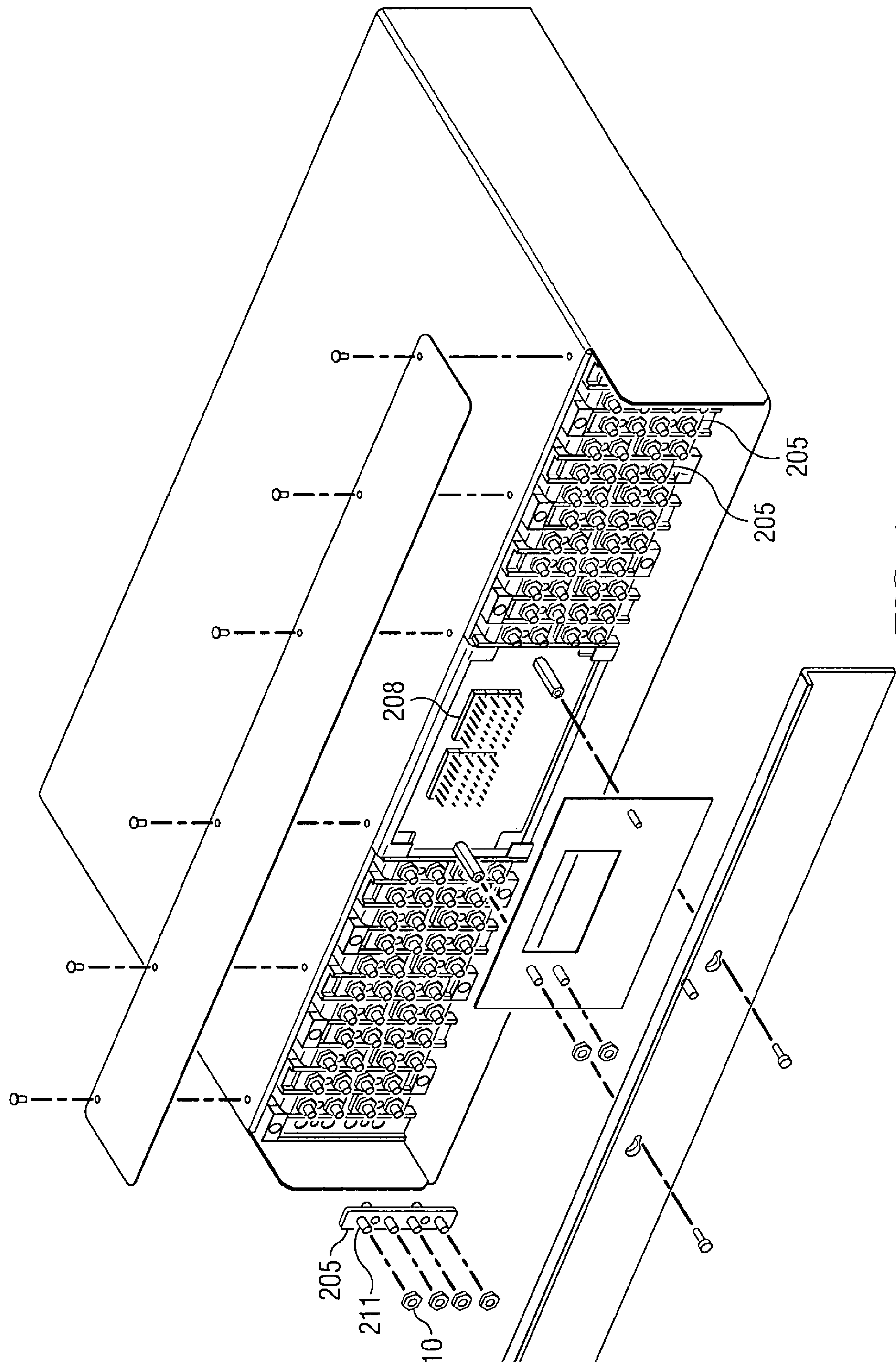


FIG. 4

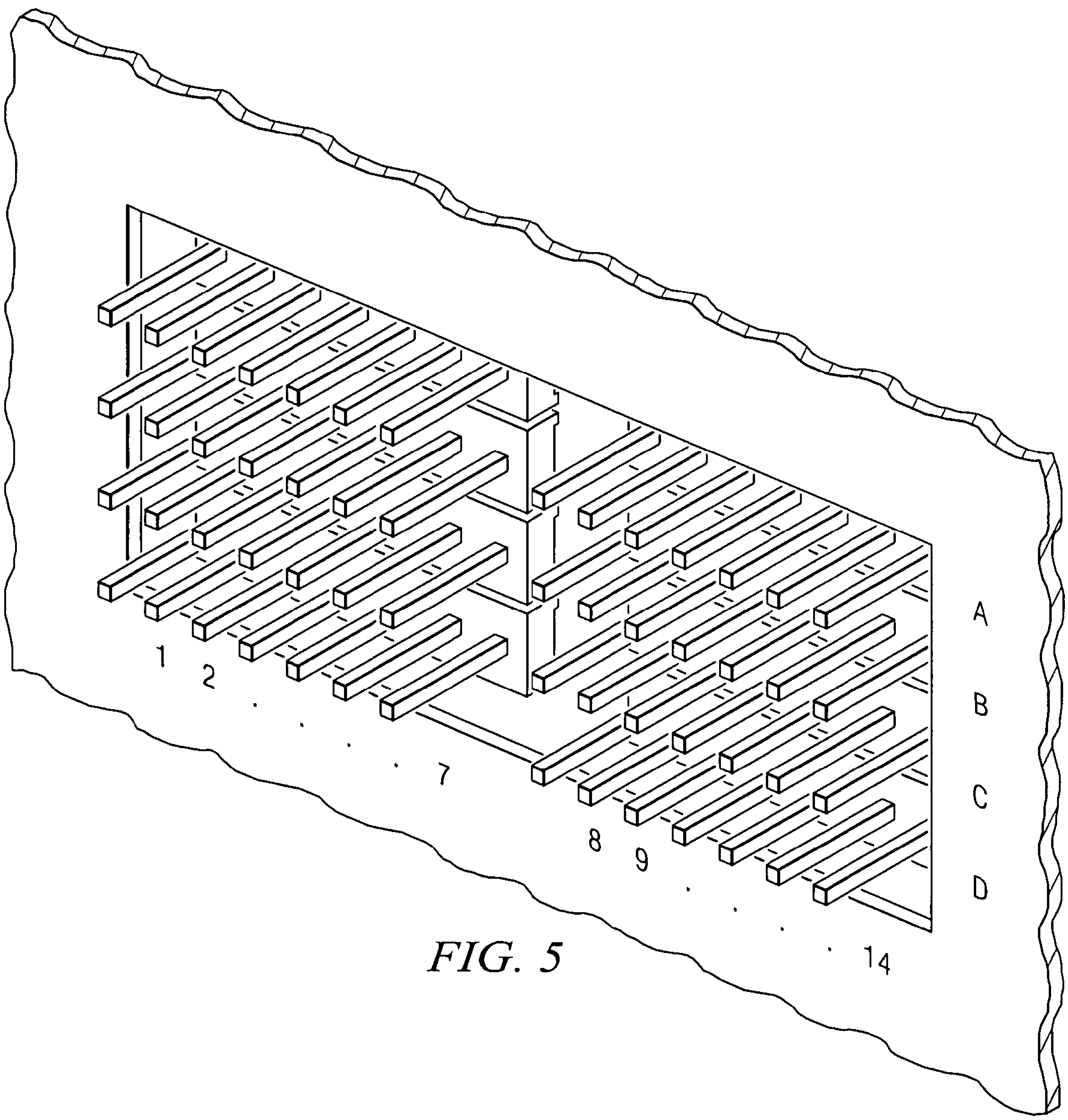


FIG. 5

POWER DISTRIBUTION SYSTEM

RELATED APPLICATION

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Application No. 61/102,039 filed Oct. 2, 2008, entitled "System and Method for Connecting Power Distribution Unit".

TECHNICAL FIELD

This invention relates generally to a power distribution system, and more particularly to a back-wiring board configured to minimize wiring within the power distribution system.

BACKGROUND

Telecommunications networks use a plurality of network nodes and communication channels to rapidly communicate large amounts of data through the network. The nodes of a telecommunication network may be configured to send, receive, and forward data over the communication channels of the network. Certain nodes within the network may be powered by a power distribution system. Such power distribution systems are designed to deliver power to the telecommunications equipment through a series of electrical circuits. A power distribution system, such as a circuit breaker panel, is designed to deliver power and to protect the electrical circuits from damage potentially caused by equipment overheating, a short circuit, or an overloaded circuit. Circuit breaker panels may be configured into various sizes, depending on the type and size of equipment being powered.

Circuit breaker panels typically include a plurality of contacts or conductors, such as feeder bus bars, in order to carry a load current. The bus bars are typically made of copper, aluminum, or a metal-alloy composition. Bus bars are typically either flat strips or hollow tubes, as these configurations typically allow for more efficient heat dissipation while safely carrying the maximum amount of current.

Circuit breaker panels, typically include a main printed circuit board (PCB) that is configured to detect input voltage levels from the feeder and return bus bars and sense other externally-fed input signals. The main PCB is typically hard-wired to each bus bar and each signal input. For example, the PCB may be wired to each bus bar via a cable assembly, which comprises a series of individual wires that are manually connected between the main PCB and the bus bars. Also, in the case of sensing externally-fed input signals, the main PCB may also be manually wired to a wire wrap block via a cable assembly. Each of the individual wires of the cable assembly are wrapped to each pin of the wire wrap block. However, the process of manually wiring the bus bars and wire wrap block to the main PCB can be time and cost intensive, in addition to providing an increased possibility for mis-wiring within the power distribution unit. Therefore, there is a need for a system and method for determining the system voltage levels of the bus bars and for sensing other input signals, without the use of manually wired cable assemblies in the power, within the power distribution system.

SUMMARY

In one embodiment, a power distribution unit is provided. The power distribution unit includes a plurality of bus bars for conducting electricity within the power distribution unit. The power distribution unit further includes a first circuit board for controlling the operation of the power distribution unit and a second circuit board coupled to the first circuit board, wherein the second circuit board is configured to connect each of the plurality of bus bars to the first circuit board, such that the second circuit board is configured to receive a voltage signal from each of the plurality of bus bars and transmit the voltage signals to the first circuit board. The power distribution unit also includes a plurality of wire-wrap pins integrated into a surface of the second circuit board, wherein the wire-wrap pins are configured to receive data input signals and to transmit the data input signals to the first circuit board via the second circuit board.

In another embodiment, a power distribution system having a main circuit board configured to control the operation of the power distribution system is provided. The power distribution system includes a primary circuit board configured to control the operation of the power distribution system and a plurality of bus bars for conducting electricity within the power distribution system. The power distribution system further includes a back-wiring board coupled to the primary circuit board, the back wiring board being further configured to be coupled with the plurality of bus bars, wherein the back-wiring board is configured to receive a voltage signal from each of the plurality of bus bars. The back-wiring board is configured to include a plurality of wire-wrap pins, such that the wire-wrap pins are integrated into a surface of the back-wiring board, wherein the wire-wrap pins are configured to receive data input signals.

In yet another embodiment, a back-wiring board is provided. The back-wiring board includes a plurality of connectors configured to secure a plurality of bus bars to the back-wiring board, such that the back-wiring board is configured to receive a voltage signal from the plurality of feeder bus bars. The back-wiring board further includes a plurality of wire-wrap pins integrated into a surface of the back-wiring board, wherein the wire-wrap pins are configured to receive data input signals, and a right angle connector configured to couple the back-wiring board to a second circuit board.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a power distribution unit including a cable assembly system;

FIG. **2** illustrates a power distribution unit having a back-wiring board connecting to the main printed circuit board package according to one embodiment of the present invention;

FIG. **3** illustrates an exploded view of the feeder bus bar connections within the power distribution unit;

FIG. **4** illustrates a back panel view of a power distribution unit; and

FIG. **5** illustrates a magnified view of the wire-wrap pin block.

DETAILED DESCRIPTION

FIG. **1** illustrates an embodiment of a power distribution unit (PDU) **100**. In one embodiment, PDU **100** may be used to power equipment at a telecommunications network node. PDU **100** may be configured to deliver power to the network node and to protect the node equipment from damage through a series of electrical components. In this embodiment, PDU **100** primarily includes a frame **102**, a main printed circuit board **104**, a plurality of bus bars (**105**, **106**), a wire-wrap block **108**, and a plurality of connectors **110** and cable assemblies (**120**, **130**).

Frame **102** is configured as a multi-sided panel, in order to house electrical components of PDU **100**. Main printed circuit board **104** (PCB **104**) is generally centrally positioned within PDU **100**. PCB **104** is configured to sense voltage changes within PDU **100**, in addition to being configured to receive alarm input signals transmitted from external telecommunication equipment, for example external customer devices.

PDU **100** includes a plurality of bus bars **105**, **106** of both positive and negative voltage potential. Each circuit within PDU **100** includes a top and bottom feeder bus bar **106** and a single return bus bar **105**. Each of the feeder bus bars **106** carry a negative voltage potential (preferably −48 volts), while return bus bars **105** (shown in FIG. **3**) carry a positive voltage potential. Bus bars **105**, **106** of PDU **100** may be a strip of copper or aluminum used to conduct electricity. The size of the bus bars may be determinative of the maximum amount of current that may be carried on each bus bar within PDU **100**. Preferably, bus bars **105**, **106** may be configured to be flat strips of either copper or aluminum or some other form of conductive material capable of transmitting current and properly allowing the dissipation of heat from each bus bar within PDU **100**.

Each of the plurality of feeder bus bars **106** may be covered by some form of insulation (not shown in FIG. **1**). The insulation may be configured to protect each feeder bus bar **106** from accidental or inadvertent contact within PDU **100**. In the present embodiment, the feeder bus bars **106** may be covered by insulation in addition to being protected by the enclosure (not shown) of PDU **100**. Each of feeder bus bars **106**, in FIG. **1**, are secured to back panel **112** of frame **102**. Back panel **112** also includes a plurality of connectors **110** in order to secure each bus bar **106** within the enclosure of PDU **100**. Bus bars **105** and **106** are assembled together by assembling studs **211** (shown in FIG. **3**) with connectors **110**, such that studs **211** from bus bars (**105**, **106**) pass through back panel **112**, in order to couple with connectors **110** and provide connectivity within each circuit.

Back panel **112** further includes a plurality of wire-wrap pins, referred to as wire-wrap block **108**. Wire-wrap block **108** may be connected to PCB **104** via cable assembly **130** (not shown). Cable assembly **130** is used to connect PCB **104** to the alarm inputs of wire-wrap block **108**. Cable assembly **130** provides a connection for transmitting customer alarm inputs back to main PCB **104**. Each of the individual wires of cable assembly **130** may be manually wrapped to each pin of wire-wrap block **108**.

Additionally, the connection between main PCB **104** and bus bars **105**, **106** may be performed by providing cable assembly **120** as a separate set of leads between PCB **104** and each bus bar **105**,**106**. Cable assembly **120** may be used in order to sense power on each bus bar circuit, in order to determine if the bus bars are powered. In this embodiment, the cable assemblies **120** and **130** comprise a series of individual wires that are manually connected from main PCB **104** to each of the plurality of bus bars **105**, **106** or to each pin of wire-wrap block **108**. In some cases, manual wiring may be problematic due to the increased likelihood of mis-wiring and lack of physical space necessary to connect each of the cable assemblies to the required inputs (i.e., bus bars **105**, **106** and wire-wrap block **108**), in addition to the fact that the process of manually wiring bus bars **105**, **106** and wire wrap block **108** to the main PCB can be time and cost intensive.

FIG. **2** illustrates a power distribution unit (PDU **200**) having a back-wiring board (BWB **212**) connected to the main printed circuit board. In this embodiment, PDU **200** primarily includes a frame **202**, a main printed circuit board **204**, a plurality of bus bars **205**, **206**, an integrated wire-wrap block **208**, and a back-wiring board **212**.

Frame **202** is configured as a multi-sided panel, in order to house certain electrical components of PDU **200**. Main printed circuit board (PCB) **204** is generally centrally positioned within PDU **200**. PCB **204** is used to connect the various electrical components of PDU **200** using the conductive traces within the substrate of PCB **204**. PCB **204** is configured to sense voltage changes within PDU **200**, in addition to being configured to receive alarm input signals transmitted from external customer devices via wire-wrap block **208**. In the illustrated embodiment, PDU **200** includes twelve circuits, wherein each circuit includes a top and bottom feeder bus bar **206** and a single return bus bar **205**.

FIG. **2** further illustrates BWB **212** configured to include a plurality of conductive traces within its substrate, in order to provide a connection from main PCB **204** to return bus bars **205** and feeder bus bars **206**, in addition to connecting to the alarm signal inputs provided by wire-wrap block **208**. Return bus bars **205** and feeder bus bars **206** include a plurality of studs **211**, which enable connectivity within each circuit of PDU **200**. Connectors **210** are coupled to studs **211** (shown in FIG. **3**) of bus bars **205**, **206** and are used to secure bus bars **205**, **206** within PDU **200**. In particular embodiments, when bus bars **205**, **206** are secured against BWB **212** using connectors **210** and studs **211**, electrical connectivity is established between the bus bars **205**, **206** and BWB **212** through conductive pads on the BWB **212** that contact the connectors **210**.

Wire-wrap block **208** is configured to be integrated into BWB **212**. The integration of wire-wrap block **208** into BWB **212** eliminates the need for wire-wrapping connections or point-to-point cable connections between the wire-wrap block and PCB **204**.

BWB **212** further includes BWB connector **220**, which provides a connection between the back-wiring board **212** and main PCB **204**. BWB connector **220** may be a right angle connector, which provides electrical connectivity between BWB **212** and main PCB **204**. Through BWB connector **220**, BWB **212** is configured to transmit voltage sense signals and wire-wrap alarm inputs to PCB **204**, without requiring a separate cable assembly to main PCB **204** from bus bars **205**, **206** and wire-wrap block **208**. The above-described, preferred embodiment eliminates the need for manual wiring between main PCB **204** and each of bus bars **205**, **206** and each of the alarm signal inputs of wire-wrap block **208**. In this embodiment, manual wiring is replaced by the conductor traces within the substrate of BWB **212**, in order to connect main PCB **204** with return bus bars **205**, feeder bus bars **206**, and wire-wrap block **208**.

FIG. **2** further illustrates a front panel of PDU **200**. The front panel preferably includes a plurality of indicators, such as indicator lights, in order to denote that an alarm has been triggered within the power distribution unit. The indicator lights preferably include fuse **242**, minor alarm **244**, major alarm **246**, and critical alarm **248**. Fuse **242** indicates that a circuit breaker has been tripped within PDU **200**. Minor alarm **244**, major alarm **246**, and critical alarm **248** are each triggered by the external alarm input signals received via wire-wrap pins **208** (shown in FIG. **2**). For example, in one embodiment, PDU **200** may be used to power telecommunications equipment. The alarm signals of the telecommunication equipment may be connected to the wire-wrap pins **208**, wherein pins **208** extend externally from PDU **200**. Minor alarm **244** may be triggered to denote a minor failure within the powered equipment (e.g., a single fan failure in the telecommunications equipment). Major alarm **246** may be triggered to denote major failure within the equipment (e.g., multiple fan failures in the equipment or loss of a single power feed), which may result in a system malfunction. Critical alarm **248** may be triggered to denote a serious system failure, which may result in a complete system crash (e.g., loss of dual power feeds). Each of the indicators (**242**, **244**, **246**, **248**) is configured to denote whether an external alarm has been triggered and transmitted to main PCB **204** via wire-wrap pins **208** of BWB **212**.

FIG. **3** illustrates an exploded view of the feeder bus bar connections within PDU **200**. FIG. **3** further exhibits the plurality of return bus bars **205** and feeder bus bars **206**. Each circuit within PDU **200** includes a top and bottom feeder bus bar **206** and a single return bus bar **205**. Each of the feeder bus bars **206** carry a negative voltage potential, while return bus bars **205** carry a positive voltage potential. Coupled to frame **202** is front plate panel **226** and back plate panel **224**. Front plate panel **226** and back plate panel **224** are configured for securing bus bars **205** and **206** in place via connectors **210** and studs **211**. The plurality of bus bars **205**, **206** are preferably configured to include a plurality of studs **211**. Studs **211** are configured to couple with connectors **210**, in order to secure bus bars **205**, **206** to front plate panel **226**, back plate panel **224**, and BWB **212**. As noted above, when bus bars **205**, **206** are secured against BWB **212** using connectors **210** and studs **211**, electrical connectivity is established between the bus bars **205**, **206** and BWB **212** through conductive pads on the BWB **212** that contact the connectors **210**.

FIG. **4** illustrates a back panel view of a power distribution unit. The back panel encloses wire wrap pins **208** and return bus bars **205**, including studs **211**. Wire-wrap pins **208** are configured to extend externally from PDU **200**, in order to receive the externally-fed alarm input signals. FIG. **5** further illustrates the connection of bus bars **205** to PDU **200** via connectors **210** and studs **211**.

FIG. **5** illustrates a magnified view of wire-wrap pin block **208**. Wire-wrap pins **208** are integrated into BWB **212** in order to provide a direct connection between PCB **204** and alarm signal inputs received from external equipment (e.g., telecommunications equipment). The integrated system of wire-wrap pins **208** is configured to transmit alarm input signals to main PCB **204**, without the need for separate cable assemblies to main PCB **204**. Once alarm signal inputs are received at wire-wrap pins **208**, the signal is transmitted through BWB **212** via BWB connector **220** (as shown in FIG. **2**) thus providing an electrical connection to main PCB **204**. In one embodiment, wire-wrap pin block **208** is positioned as a grid of four rows and fourteen columns embedded into the surface of BWB **212**. However, the wire-wrap pin block **208** may be positioned in other configurations to accommodate the requirements of BWB **212** or the customer alarm input signals.

The herein described power distribution unit **200** is configured to eliminate the need for manual point-to-point wiring and manual wire-wrapping, in addition to further eliminating the requirement to insulate the bus bars. Such an embodiment enables voltage sense signals and wire-wrap alarm inputs to be transmitted directly to main PCB **204**, without additional cable assemblies, through BWB **212**.

While exemplary embodiments are illustrated in the Figures and described above, it should be understood that these embodiments are offered by way of example only. Accordingly, the present innovation is not limited to a particular embodiment, but extends to various modifications that nevertheless fall within the scope of the appended claims. The order or sequence of any processes or method steps may be varied or re-sequenced according to alternative embodiments. Describing the innovation with Figures should not be construed as imposing on the invention any limitations that may be present in the Figures.

The foregoing description of embodiments of the innovation has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention. The embodiments were chosen and described in order to explain the principals of the innovation and its practical application to enable one skilled in the art to utilize the innovation in various embodiments and with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A power distribution unit, comprising:
- a plurality of bus bars for conducting electricity within the power distribution unit;
- a first circuit board for controlling the operation of the power distribution unit;
- a second circuit board electrically coupled to the first circuit board, wherein the second circuit board electrically couples each of the plurality of bus bars to the first circuit board such that voltage signals received by the second circuit board from each of the plurality of bus bars are transmitted to the first circuit board; and
- a plurality of wire-wrap pins integrated into a surface of the second circuit board such that data input signals received by the wire-wrap pins are transmitted to the first circuit board via the second circuit board.

2. The power distribution unit of claim **1**, wherein the power distribution unit comprises a circuit breaker panel.

3. The power distribution unit of claim **1**, wherein the second circuit board comprises a back wiring board.

4. The power distribution unit of claim **1**, wherein a plurality of connectors mechanically secure the plurality of bus bars to the second circuit board.

5. The power distribution unit of claim **4**, wherein the plurality of connectors are further configured to electrically couple the plurality of bus bars to the second circuit board.

6. The power distribution unit of claim **1**, wherein the second circuit board includes a right-angle connector, the connector being configured to couple the second circuit board to the first circuit board.

7. The power distribution unit of claim **6**, wherein the right-angle connector of the second circuit board is further configured to transmit the voltage signals and the data input signals to the first circuit board.

8. The power distribution unit of claim **1**, wherein the data input signals transmitted via the wire-wrap pins comprise customer alarm input signals.

9. A power distribution system, comprising:
- a primary circuit board configured to control the operation of the power distribution system;
- a plurality of bus bars for conducting electricity within the power distribution system; and
- a back-wiring board electrically coupled to the primary circuit board, the back wiring board electrically coupled to the plurality of bus bars such that a voltage signal received by the back-wiring board from each of the plurality of bus bars is transmitted to the primary circuit board, the back-wiring board including a plurality of wire-wrap pins, the wire-wrap pins being integrated into a surface of the back-wiring board, wherein the wire-wrap pins are configured to receive data input signals and transmit the signals to the primary circuit board via the back-wiring board.

10. The power distribution system of claim **9**, wherein the power distribution system comprises a circuit breaker panel.

11. The power distribution system of claim **9**, wherein a plurality of connectors mechanically secure the plurality of bus bars to the back-wiring board.

12. The power distribution system of claim **11**, wherein the plurality of connectors are further configured to electrically couple the plurality of bus bars to the back-wiring board.

13. The power distribution system of claim **9**, wherein the back-wiring board includes a right-angle connector, the connector being configured to couple the back-wiring board to the primary circuit board.

14. The power distribution system of claim **13**, wherein the right-angle connector is further configured to transmit the voltage signals and the data input signals to the primary circuit board via the back-wiring board.

15. The power distribution system of claim **13**, wherein the right-angle connector is further configured to transmit the data input signals to the primary circuit board via the back-wiring board.

16. The power distribution system of claim **9**, wherein the data input signals comprise customer alarm input signals.

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